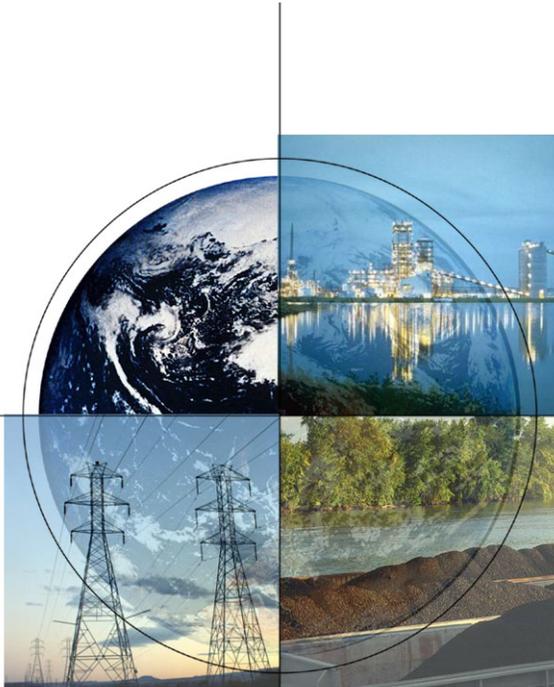


DOE-NETL Air Quality Research Program



*U.S. Department of Energy
Office of Fossil Energy*

*National Energy Technology
Laboratory (NETL)*

**William W. Aljoe, Project Manager/Program Coordinator
National Energy Technology Laboratory**



NETL: R&D in Fossil Energy Supply, Delivery, and Use

Electric Power Using Coal



Coal Production



Environmental Control



V21 Next Generation



Carbon Sequestration

Clean Liquid Fuels



Exploration & Production



Refining & Delivery



Alternative Fuels



Future Fuels

Natural Gas



Exploration & Production



Pipelines & Storage



Fuel Cells



Combustion Turbines

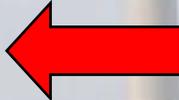


DOE Office of Fossil Energy Innovations for Existing Plants (IEP) Program

- **Goal**

- Enhance environmental performance of existing fleet of coal power plants and advanced power systems

- **R&D Approach**

- Environmental Research 
 - Which pollutants should we control, and by how much?
- Pollution Control Technology
 - How can we (economically) control these pollutants?



Bureaucratic Terminology

- **“Innovations for Existing Plants (IEP) Program”**
 - DOE Office of Fossil Energy (Funding)

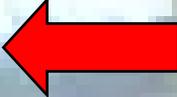
a.k.a.

- **“Environmental & Water Resources Product Line”**
 - National Energy Technology Laboratory (Implementation)



NETL Environmental & Water Resources

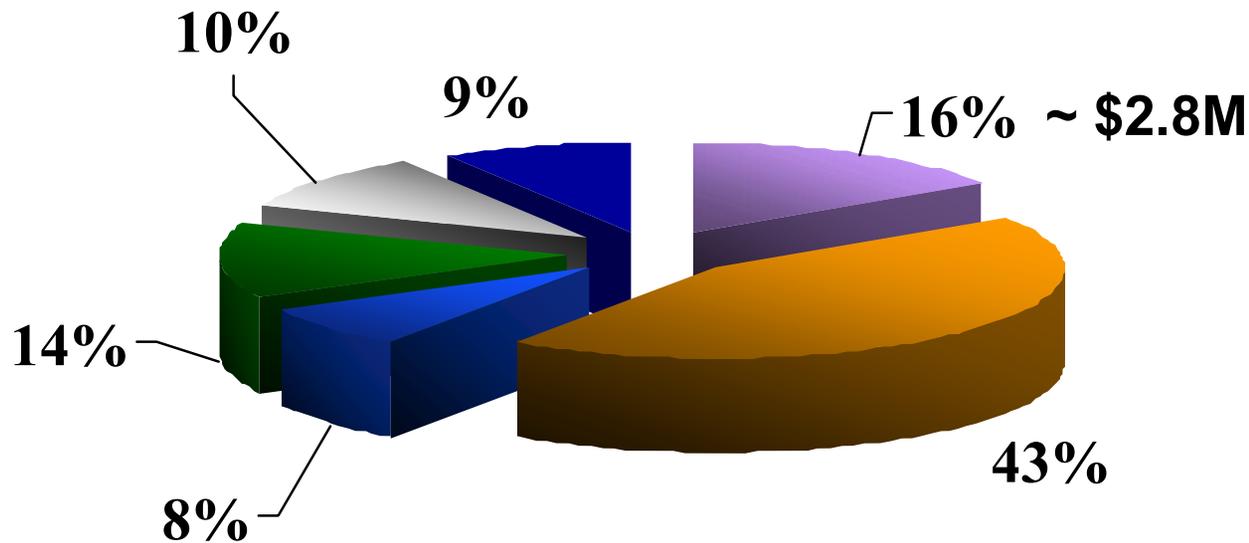
“Product Line”

- **Technology Manager: Tom Feeley**
- **6 Technical Focus areas:**
 - Air Quality Research 
 - Coal Utilization Byproducts (CUB)
 - Power Plant Water Issues
 - Mercury Emissions Control
 - Advanced NO_x Emissions Control
 - PM/SO₃ Emissions Control



Innovations for Existing Plants

NETL FY04 Funding (approx. \$18 million)



- Air Quality
- Mercury
- NOx
- CUB
- Water
- Other



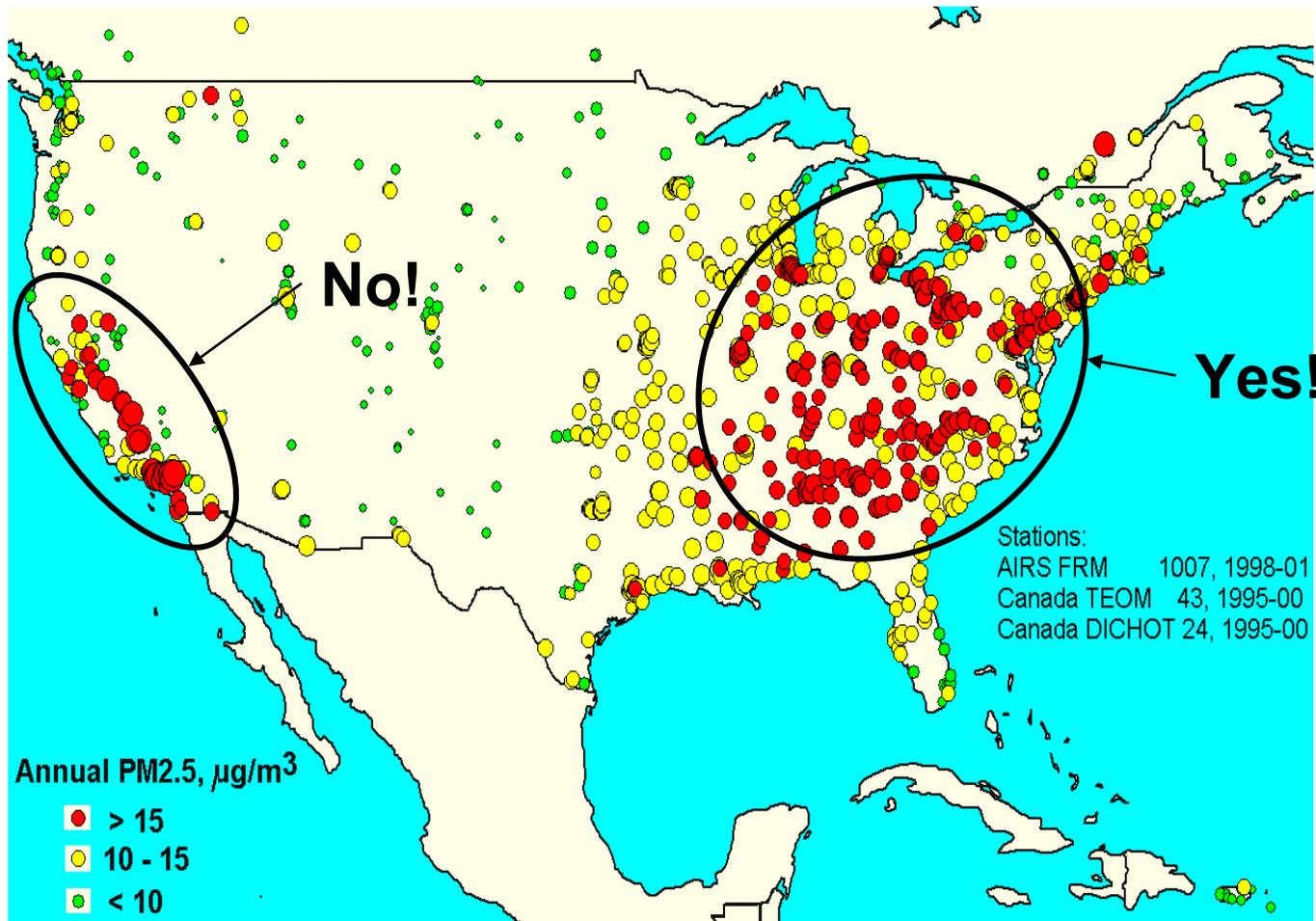
NETL Air Quality Research Program

- **Recent Focus (1999-2003): Atmospheric PM_{2.5}**
 - Ambient monitoring & analysis
 - Emissions characterization
 - Predictive modeling & evaluation

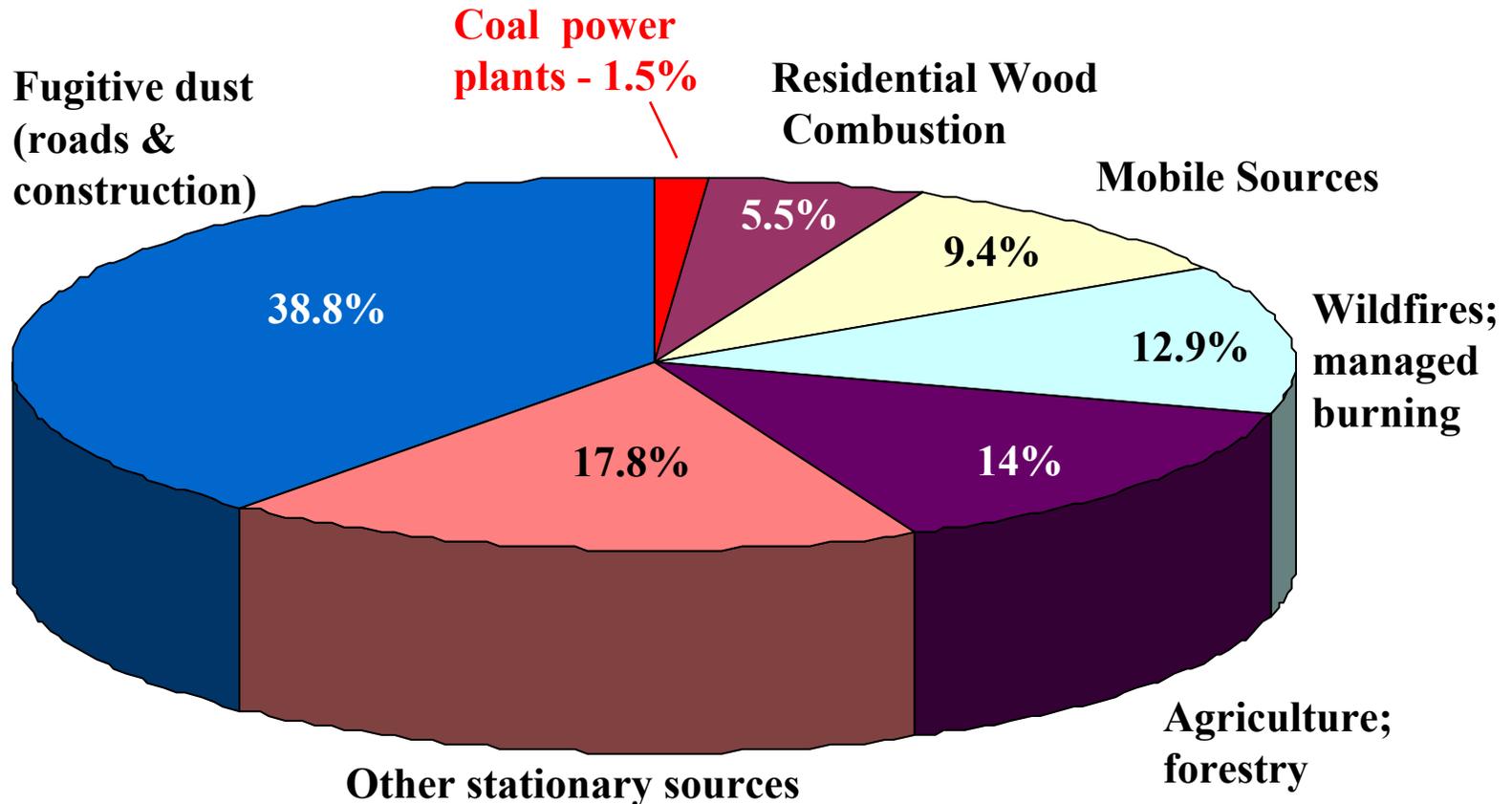
- **New Initiatives:**
 - Health effects of PM_{2.5} components
 - Atmospheric Hg measurement & modeling



Do Coal Plant Emissions Cause PM_{2.5} Problems? (A Simplistic View)



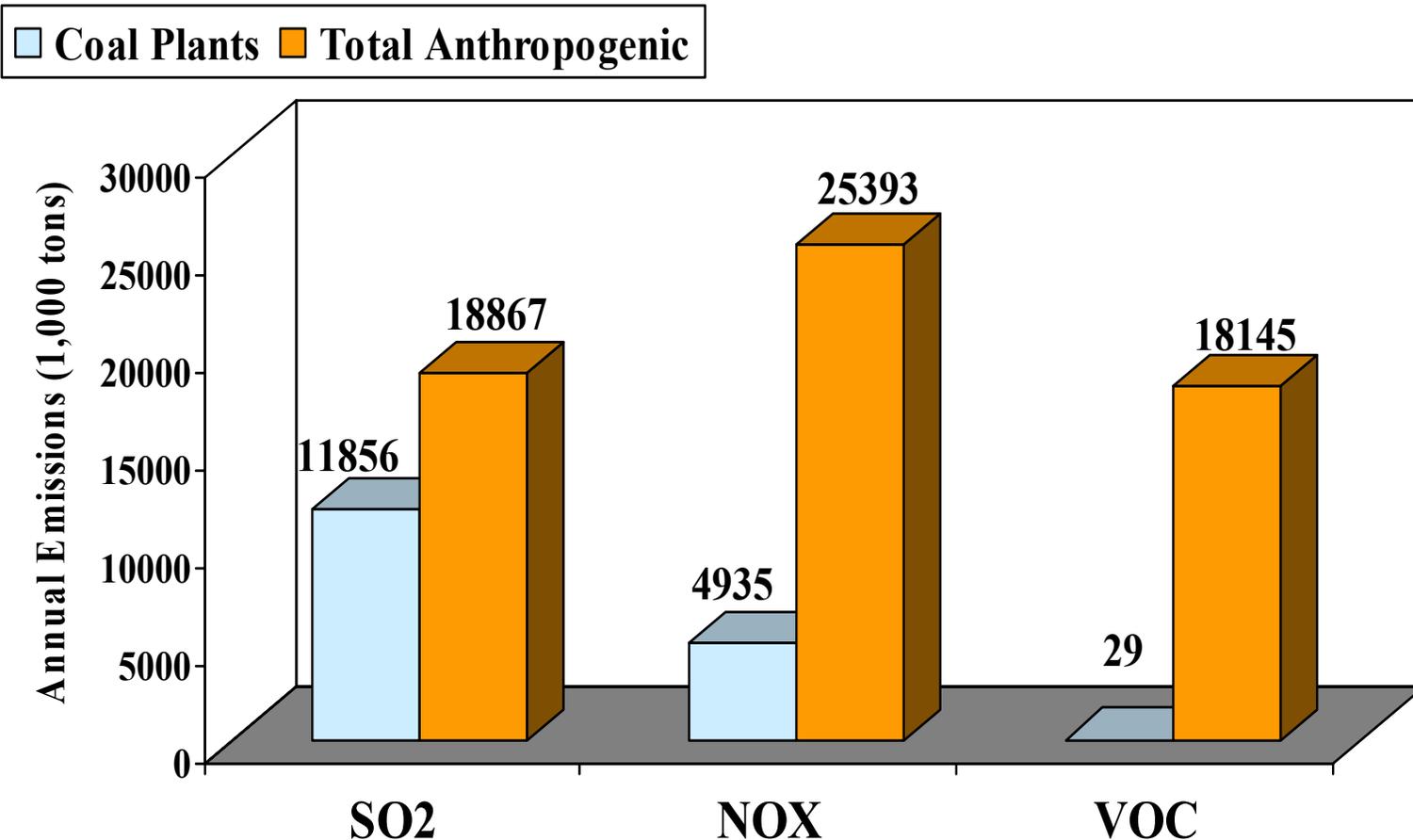
U. S. 1999 Primary PM_{2.5} Emissions



Source: National Air Pollution Emission Trends, 1999 (EPA-454/R-01-0049-80-009, March 2001)



1999 U.S. Secondary PM_{2.5} Precursor Emissions

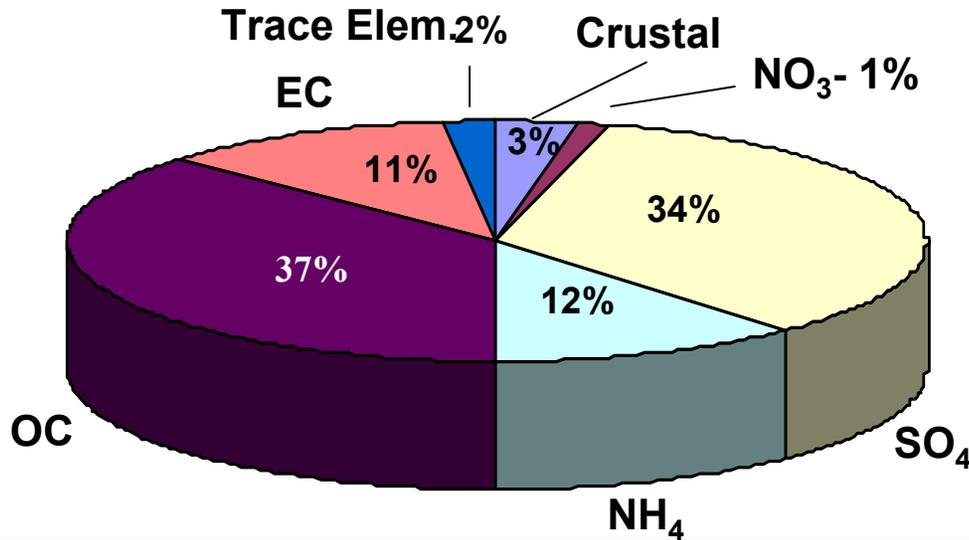


Source: National Air Pollution Emission Trends, 1999 (EPA-454/R-01-0049-80-009, March 2001)



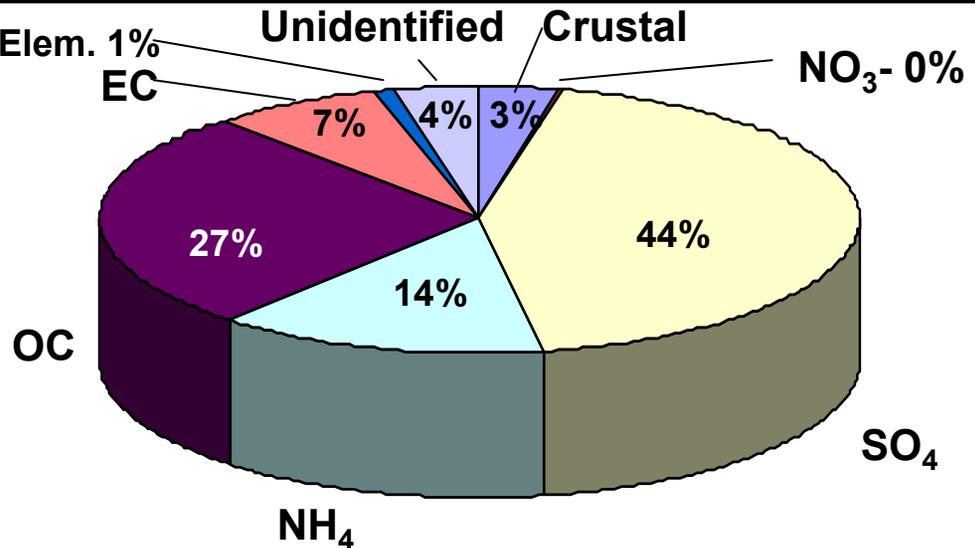
Typical PM_{2.5} Composition in Western PA

Summer 1999



Urban (Pittsburgh)
avg. of 39 samples

Rural (Greene County)
avg. of 10 samples



PM_{2.5} NAAQS and Coal Plants

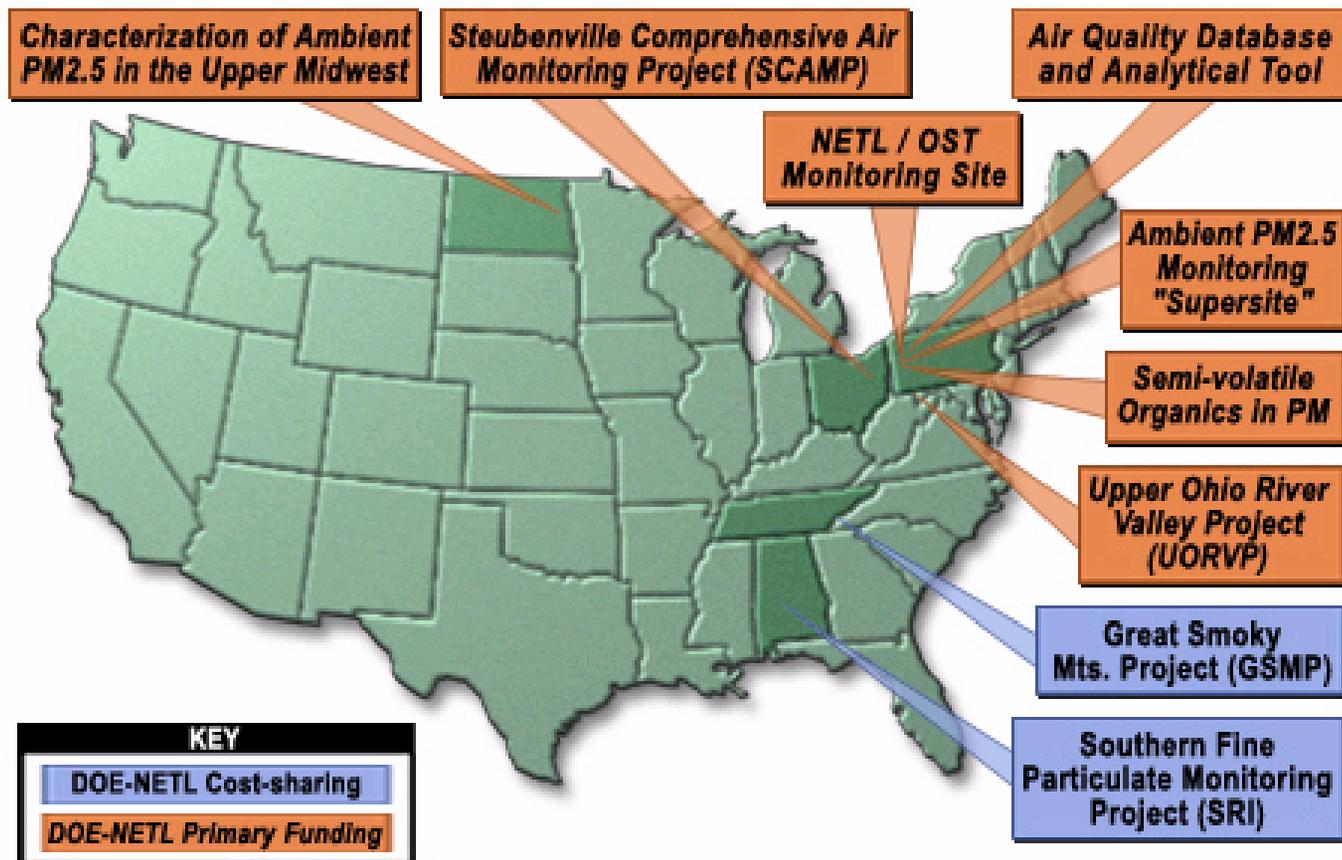
General Rules-of-thumb

- **Reductions in primary PM_{2.5} emissions will not help compliance with mass-based standards**
 - Fly ash <<1% of ambient PM_{2.5}
- **Widespread reductions of SO₂ and NOx emissions will occur under existing programs**
 - Acid Rain, NOx SIP call, regional haze
- **Reductions in coal plant emissions will not significantly reduce carbon component of PM_{2.5}**
 - Coal plants produce minimal EC, OC, CO, VOC's

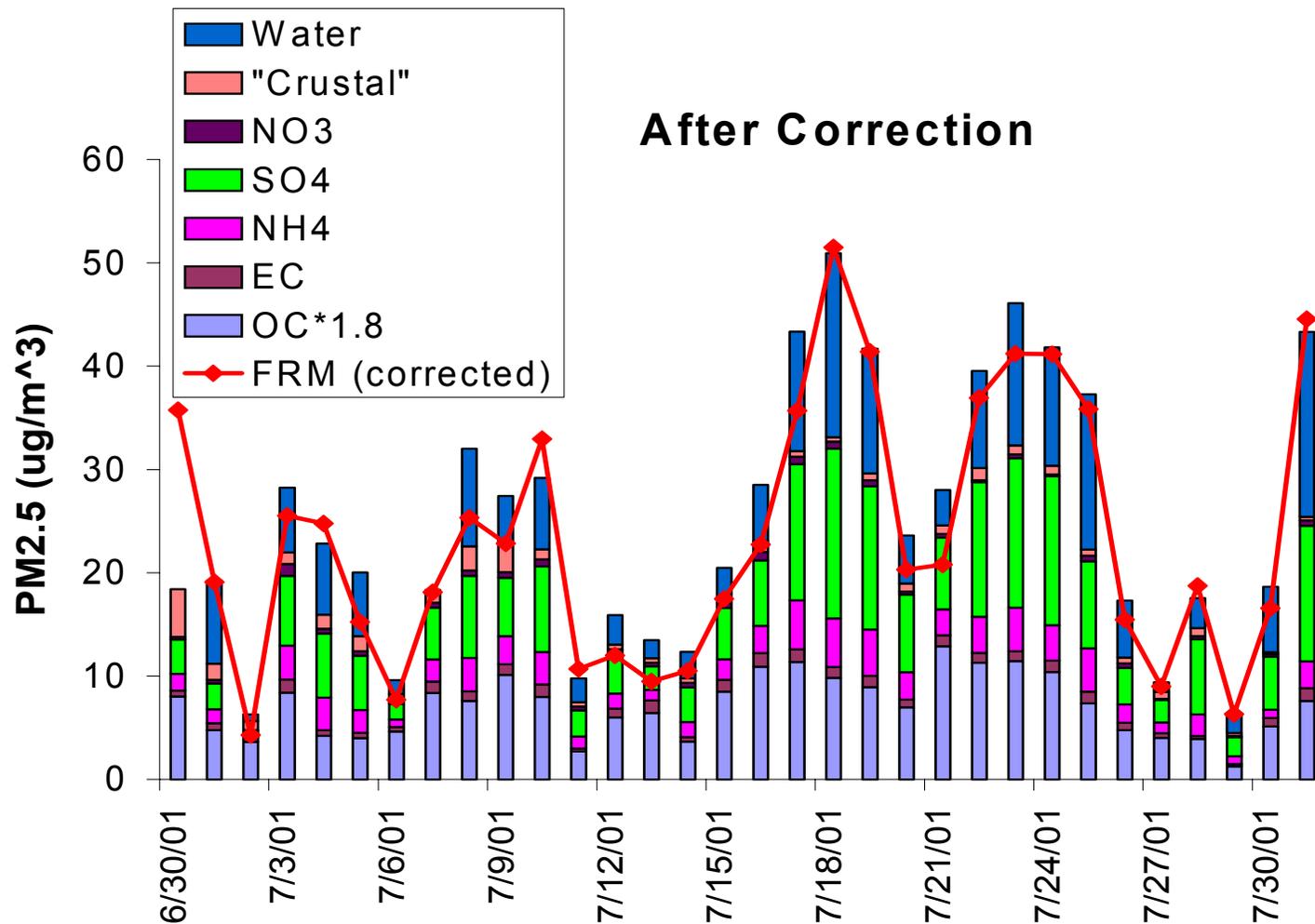


Ambient Monitoring & Analysis

NETL Project Portfolio



PM_{2.5} mass and composition CMU-Pittsburgh PM Supersite



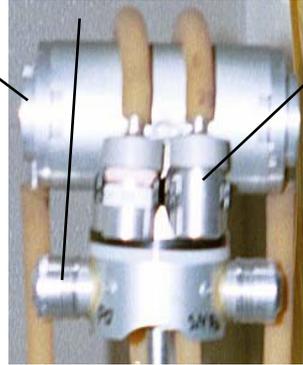
Steubenville, OH Study (SCAMP)

Harvard Multi-pollutant Sampler

O_3 , NO_2 , SO_2

$PM_{2.5}$ Mass

EC, OC, SO_4



Outdoor



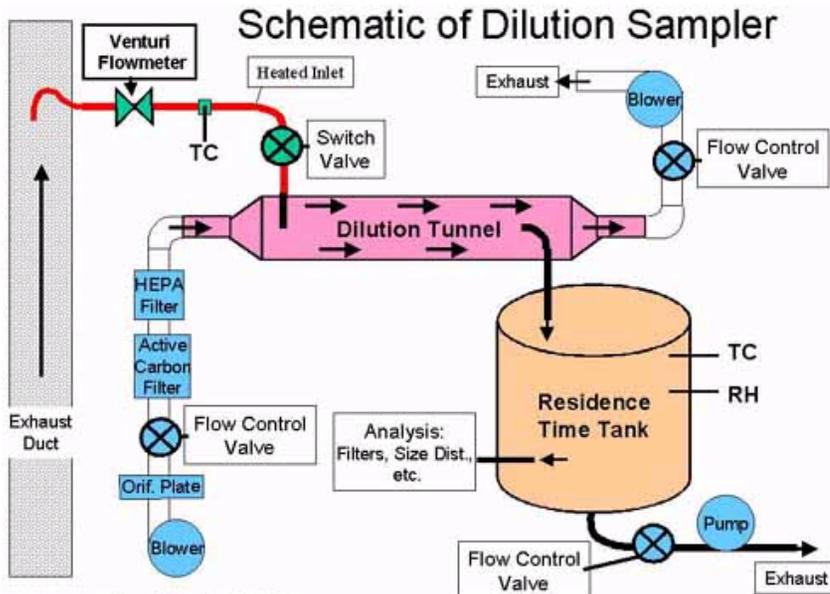
Indoor



Personal

PM_{2.5} Emissions Characterization Projects

Dilution Sampler for Coal Plants



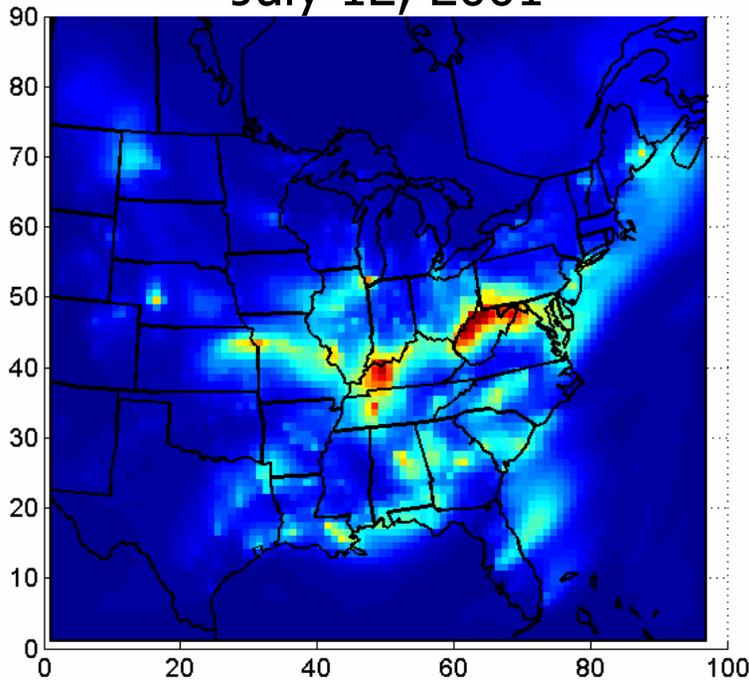
SO₂ to SO₄ Conversion in Scrubber Plume



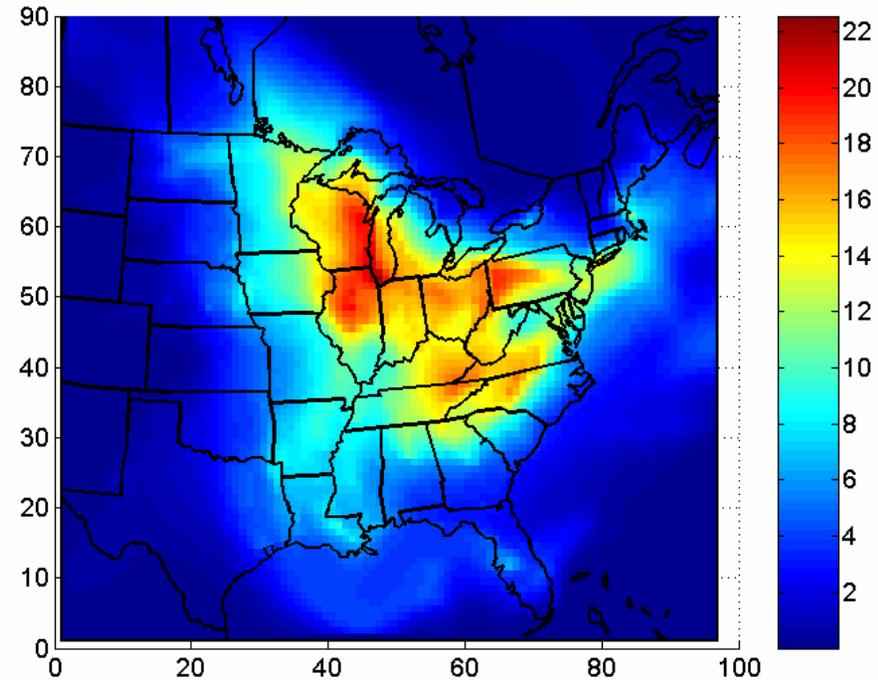
Regional PM_{2.5} Modeling

- 36x36 km grid, 14 levels up to 6 km
- 10 aerosol sections, 13 aerosol species
- 20 million differential equations
- 8 CPU hours on a PC per simulation day (EQUilibrium module)

July 12, 2001



July 17, 2001



Predicted PM_{2.5} Sulfate



What Will Happen to $PM_{2.5}$ When We Reduce SO_2 and NO_x Emissions from Coal Plants?

- SO_2 emission reductions will cause ambient $PM_{2.5}$ sulfate to decrease
 - Less regional haze, “Clear(er) Skies”
- SO_2 and NO_x emission reductions may or may not reduce ambient $PM_{2.5}$ mass
 - NO_x contribution from mobile sources
 - Substitution of NH_4NO_3 for $(NH_4)_2SO_4$



Will SO₂ and NO_x Reductions from Coal Plants Improve Human Health?

- Epidemiology says lower PM_{2.5} mass = better health, but ...
- Toxicology: all PM components are not equally toxic
- Atlanta epidemiology study (ARIES):
 - No association between sulfates and adverse health effects
 - Significant association between carbon and health effects
- Few realistic studies of toxicity of secondary sulfates & nitrates vs. other PM_{2.5} components
- *DOE-FE believes a better assessment of health benefits resulting from coal plant emission reductions is needed*



PM Health Research: Policy Applications

- **Better models of “externalities” of power plant emissions**
 - Health improvement = “Benefit” in cost-benefit analysis
- **Current paradigm:**
$$\Delta\text{Health Effects} = f(\Delta\text{PM}_{\text{mass}}, \Delta\text{Gases}, \dots)$$
- **New (better) paradigm:**
$$\Delta\text{Health Effects} = f(\Delta\text{PM}_{\text{sulfate}}, \Delta\text{PM}_{\text{EC}}, \Delta\text{PM}_{\text{OC1}}, \Delta\text{PM}_{\text{OC2}}, \Delta\text{PM}_{\text{Metal1}}, \Delta\text{PM}_{\text{Metal2}}, \dots)$$

PM Health Research: Technology R&D Applications

- Do we need more efficient SO₂ emission control technology (currently ~95%)?
- Do we need more efficient (or more selective) primary PM emission control technology (currently >99.5%)?
- What is the cost-effectiveness of new emission control technology compared with alternative coal-to-energy technologies (gasification)?



PM Health Research at NETL

- **Current Efforts**

- Laboratory development of “coal combustion atmospheres” (NERC Workshop)
- TERESA project (EPRI)
 - Animals exposed to “aged” emissions from full-scale coal power plant
 - Mobile laboratories for plume reactions and animal exposure

- **New Solicitation – FY04**

- Epidemiology (Retrospective - Pittsburgh only)
- Toxicology: Focus on realistic concentrations & effects of atmospheric processes (acid catalysis)



Atmospheric Hg Studies

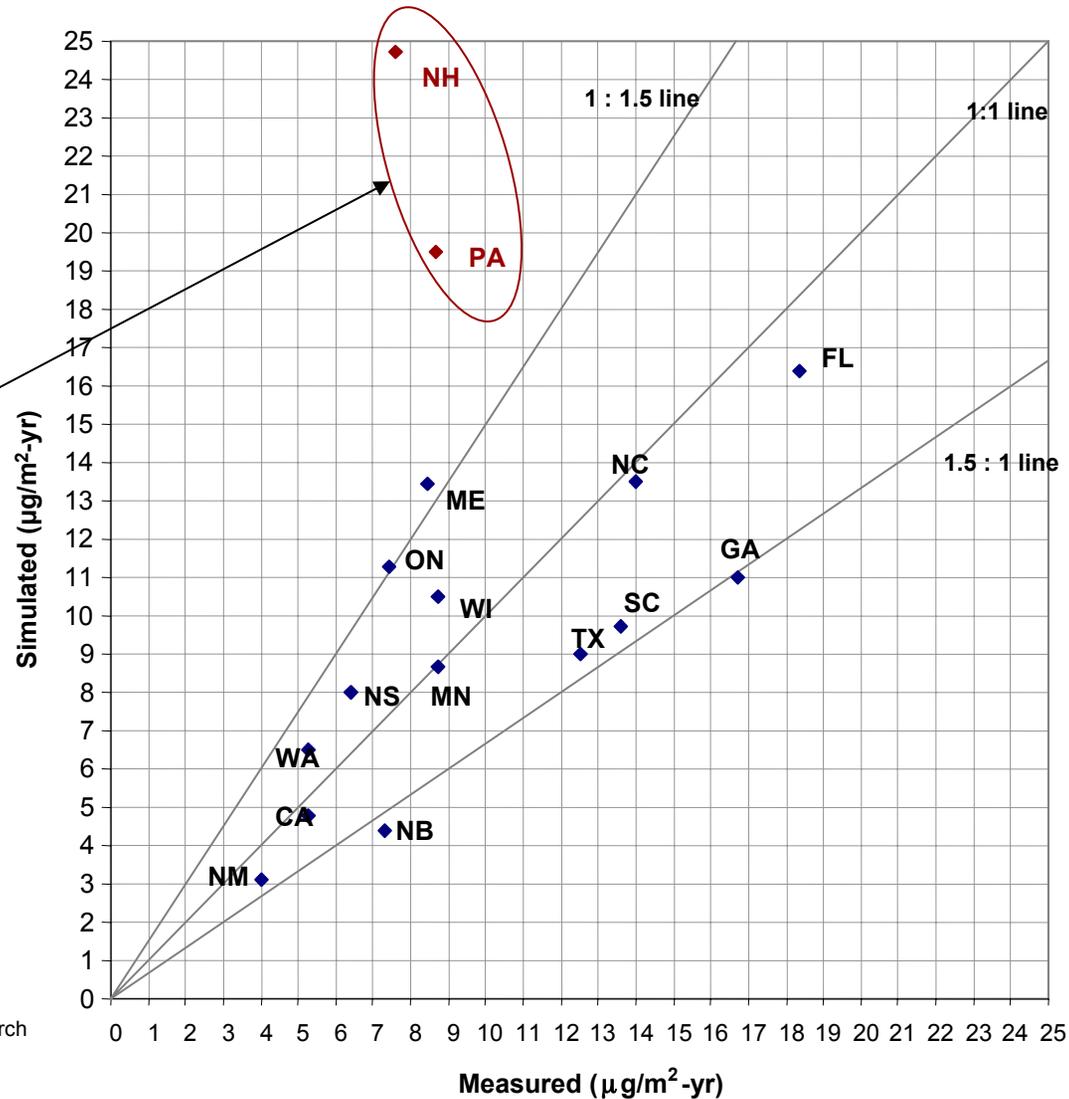
- **Elemental mercury (Hg^0) is relatively insoluble**
 - Goes into global “pool;” Residence time ~ 1 year
 - Disadvantage: Hard to capture in power plant flue gas
 - Advantage: Trading not a problem
- **Ionic mercury (Hg^{2+}) ~ 10^6 x more soluble**
 - Can be washed out of plume close to source
 - Advantage: Easier to remove from flue gas
 - Disadvantage: Trading may ignore local deposition
- **Current models overestimate wet Hg deposition in key areas**
 - Hg reduction in plumes may play a role



EPRI Hg Model Predictions vs. Observations

Average wet Hg deposition

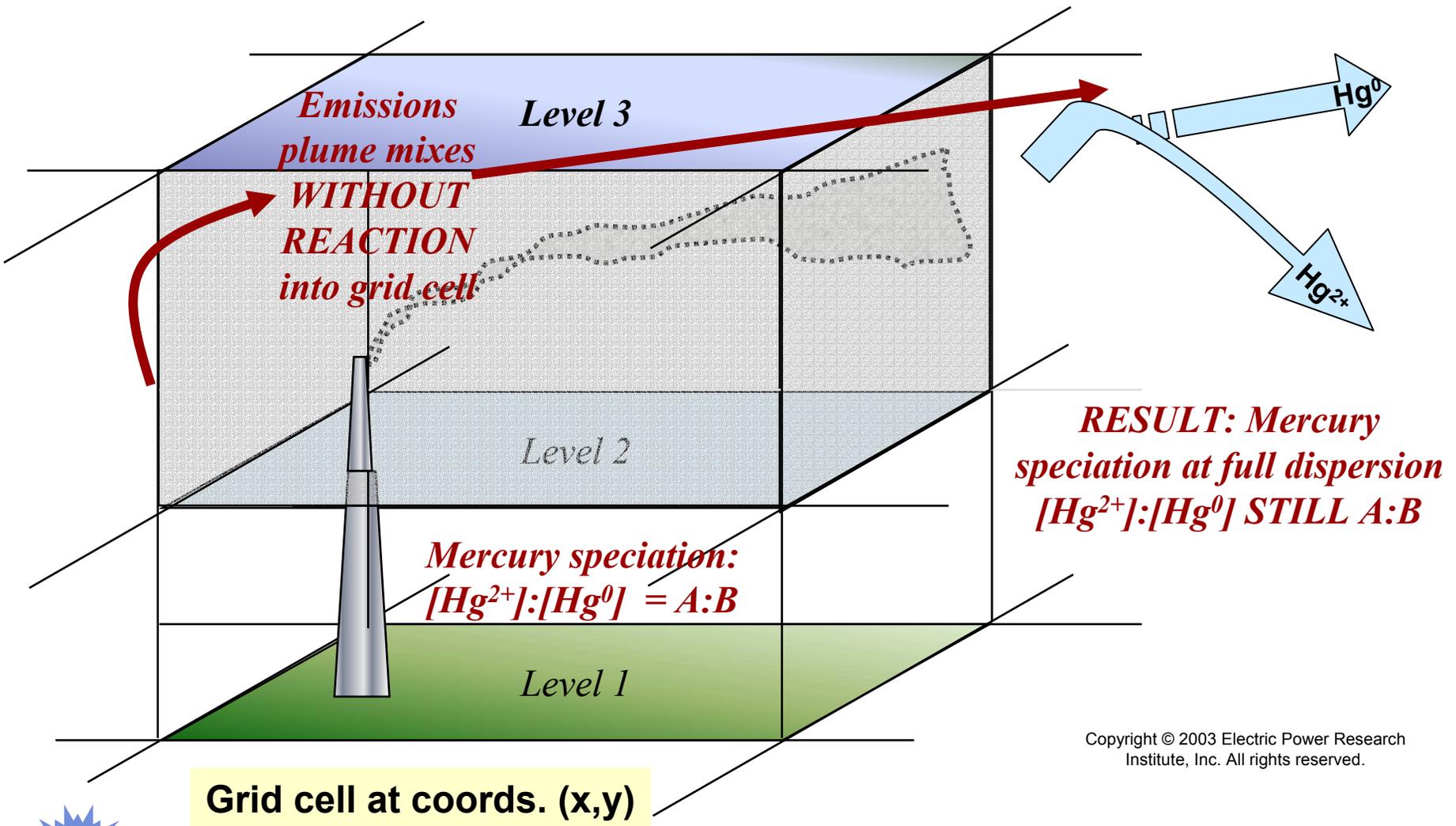
“Pennsylvania anomaly”



Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.



Plume behavior in model atmosphere



Copyright © 2003 Electric Power Research Institute, Inc. All rights reserved.



NETL Atmospheric Hg Research

- Measure Hg speciation via instrumented aircraft at various distances downwind in plumes
- Compare $\text{Hg}^{2+}:\text{Hg}^0$ ratios with in-stack measurements
- Evaluate artificial plume dilution/reaction devices
- Incorporate reactions into Hg transport and deposition models



For More Information:

Links >> Address <http://www.netl.doe.gov/coalpower/environment> ←

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY
ENVIRONMENTAL & WATER RESOURCES WEBSITE

| Home | Site Index | Feedback |

March 20, 2002

Environmental and Water Resources

Leading the way in the development of environmental science and technology

The Environmental and Water Resources Product Line is focused on the development of highly efficient and cost-effective environmental control technologies for retrofitting to existing power plants, with application to new plants as well. The Product Line also provides key scientific and technical data on emerging environmental regulatory and policy issues.

- Mercury Emissions Control
- Coal Combustion By-Products
- Air Quality Research**
- PM Emissions Control
- Advanced NO_x Emissions Control
- Energy - Water Interface

What's New
Description
Events
Mercury
CCBs
Air Quality
PM
NO_x
Water
In-House R&D
Ref. Shelf
Links
Contacts

